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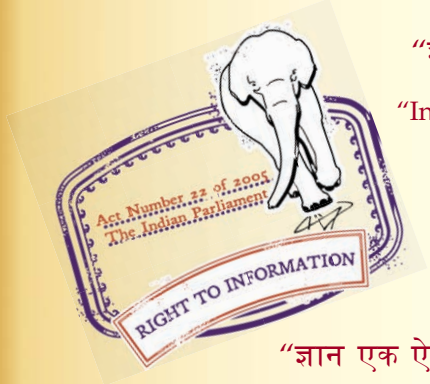

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RECOMMENDATIONS FOR THE DESIGN OF SCALES AND INDEXES FOR INDICATING INSTRUMENTS FOR SCALES OF 1 TO 2 PERCENT RESOLUTION

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August 1966

Indian Standard

RECOMMENDATIONS FOR THE DESIGN OF SCALES AND INDEXES FOR INDICATING INSTRUMENTS FOR SCALES OF 1 TO 2 PERCENT RESOLUTION

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Indian Standard

RECOMMENDATIONS FOR THE DESIGN OF SCALES AND INDEXES FOR INDICATING INSTRUMENTS FOR SCALES OF 1 TO 2 PERCENT RESOLUTION

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 6 May 1966, after the draft finalized by the Optical and Mathematical Instruments Sectional Committee had been approved by the Mechanical Engineering Division Council.

0.2 Instruments measuring different physical quantities are generally mounted together on control panels. Sometimes, the instruments are made by different manufacturers a d, therefore, it is considered desirable to adopt a uniform system of scale graduations and presentation so that all instruments 1 ay be read with speed and accuracy.

0.3 This standard lays down the recommendations to help the instrument manufacturers in the design of scales and associated indexes with a reasonable uniformity for rapid and accurate reading at a common viewing distance. The types of scales covered in this standard are straight, circular or part-circular and having 1 to 2 percent resolution.

0.4 These recommendations are intended as a guide to the designer and the maximum scale values indicated are not necessarily the preferred ones. It may be necessary to adopt other maximum scale values, depending on the use of the instruments, but the general principles indicated in these recommendations will make the scale easily readable.

0.5 The permissible variations for different dimensions of scales and indexes have not been included in this standard, and it is hoped that the manufacturers will adopt good engineering practice in assuming relevant tolerances.

0.6 In the preparation of this standard, considerable assistance has been derived from B.S. 3693 (Part-1)-1964 ' Recommendations for the design of scales and indexes, Part 1 — Instruments of bold presentation and for rapid reading ' issued by the British Standards Institution.

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1. SCOPE

1.1 This standard lays down recommendations for design of scales and associated indexes for quantitative instruments to enable rapid reading to a

resolution of about 1 to 2 percent of the scale range when read from a given maximum distance. These recommendations are applicable only to single scale instruments having dials with full circle, part circle or straight scales. These recommendations are not applicable to trans-illuminated dials nor to moving-scale with fixed index in instruments.

2. NOMENCLATURE

2.0 For the purpose of this standard, the following definitions shall apply (*see* Fig. 1 *and* 2).

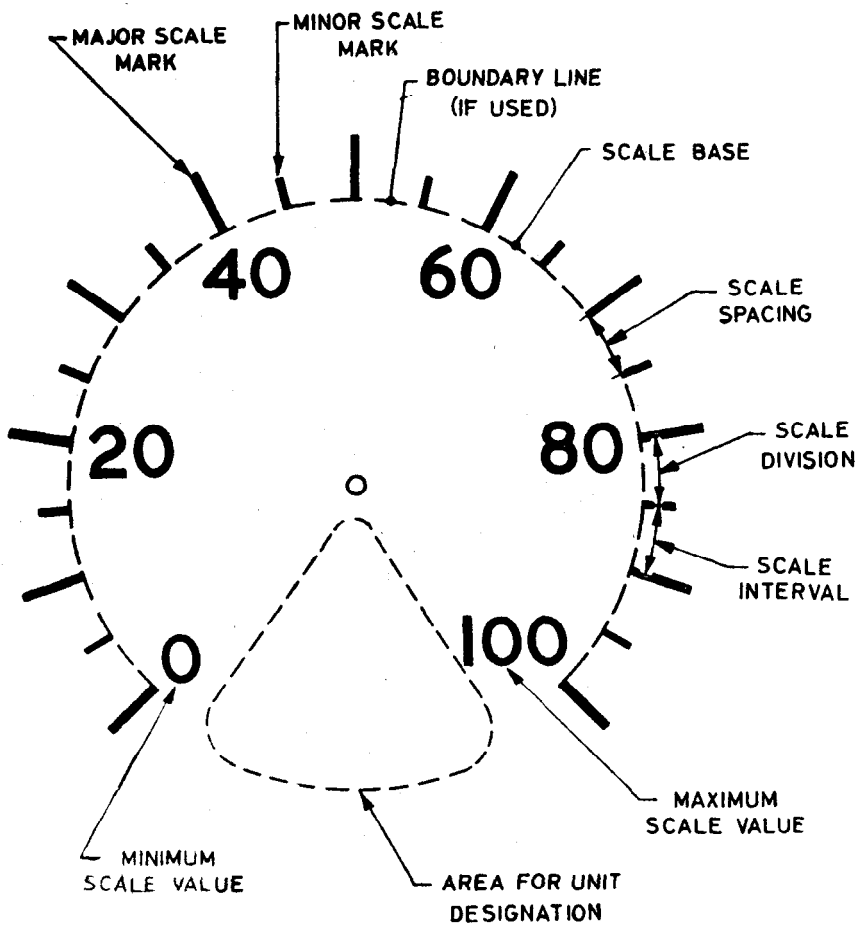
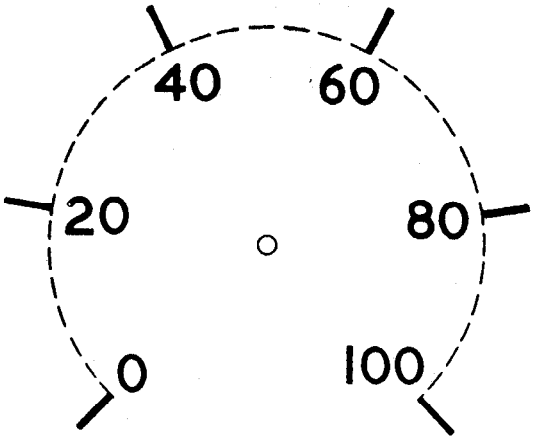
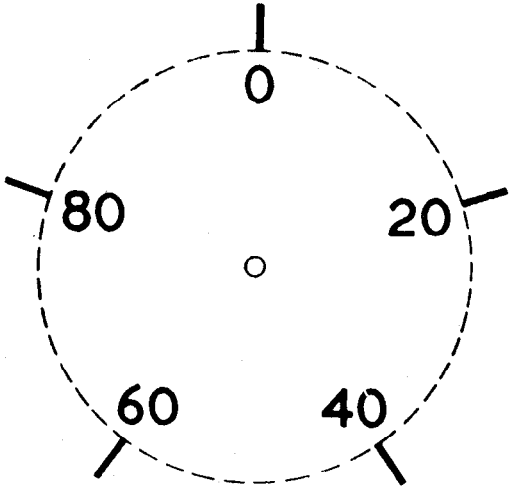


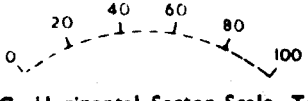
FIG. 1 NOMENCLATURE FOR DIALS AND SCALES



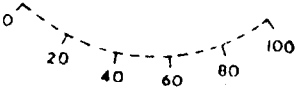
2A Part Circular Scale



2B Full Circular Scale

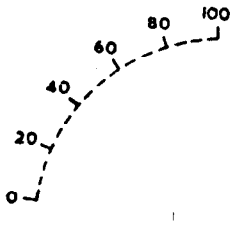


2C Horizontal Sector Scale, Top

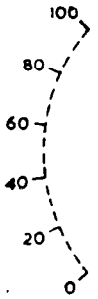


2D Horizontal Sector Scale, Bottom

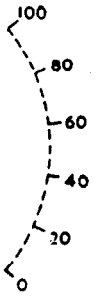
FIG. 2 ILLUSTRATIONS OF TYPES OF SCALES — *Contd*



2E Quadrant Scale, Upper Left

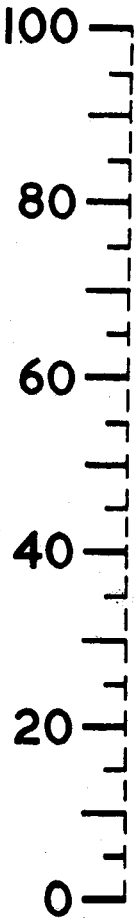


2F Vertical Sector Scale, Left Hand



2G Vertical Sector Scale, Right Hand

2H Horizontal, Straight or Edgewise Scale



2J Vertical, Straight or Edgewise Scale

FIG. 2 ILLUSTRATIONS OF TYPES OF SCALES

2.1 Index — The pointer, light-spot, liquid surface recording pen, stylus or other means, by the position of which, in relation to the instrument scale or chart, the value of the measured quantity, or the point of balance of a null-point instrument, is indicated.

2.2 Pointer — A form of index.

2.3 Scale — On an indicating instrument, the array of marks, together with any associated figuring, with relation to which the position of the index is observed. Different configurations of scales such as circular, sector and straight are shown in Fig. 2 to indicate the nomenclature.

NOTE — The scale may indicate values either directly in units of the quantity measured, or in arbitrary units requiring appropriate conversion to give the values of the measured quantities.

2.4 Linear Scale — A scale in which the scale spacing is substantially uniform.

2.5 Index Path — The line of travel, relative to the scale, of that point on the index, or on the geometric prolongation of the index, which is effective in indicating the value of the quantity measured.

NOTE — In some instruments the point on the index which is thus effective may vary with the position of the index.

2.6 Scale Base — The line, actual or implied, running from end to end of the scale, which defines, or corresponds with, the index path.

NOTE — For the purpose of these recommendations, the index path is taken to be coincidental with the ends of the scale marks nearest the index.

2.7 Scale Mark [Graduation Mark, Graduation Line, Graduation (Deprecated)] — One of the marks constituting a scale*.

2.8 Scale Length — The distance between the centre lines of the terminal scale marks, measured along the scale base.

2.9 Maximum Scale Value — The greatest value of the measured quantity which the scale is graduated to indicate.

NOTE — In multi-range instruments, this definition is to be read as applying to the particular range which the instrument is set up to measure.

2.10 Minimum Scale Value — The smallest value of the measured quantity which the scale is graduated to indicate.

NOTE — In multi-range instruments, this definition is to be read as applying to the particular range which the instrument is set up to measure.

2.11 Scale Division, Scale Subdivision (Deprecated) — The part of a scale delimited by the centre lines of two adjacent scale marks normal to the scale base.

*The term 'scale division' is defined at **2.11** and this term should not be used in the sense of definitions **2.7, 2.12** and **2.13.**

2.12 Scale Spacing — The distance measured along the scale base between the centre lines of two adjacent scale marks, normal to the scale.

2.13 Scale Interval — The increment of the measured quantity corresponding to the scale spacing*.

2.14 Scale Range — The difference between the nominal values of the measured quantities corresponding to the terminal marks.

NOTE — Scale range is conveniently expressed in the form '*A* to *B*' where *A* is the minimum scale value and *B* is the maximum scale value.

2.15 Instrument Range — The total range of values which an instrument is capable of measuring. In a single-range instrument, the instrument range corresponds to the scale range. In a multi-range instrument, the instrument range is expressed by the difference between the maximum scale value for the scale of highest values and the minimum scale value for the adjacent ranges are equal or overlapping.

NOTE 1 — Instrument range is conveniently expressed in the form '*A* to *B* continuous', or '*A* to *B* with gap *C* to *D*' for an instrument in which the whole range '*A* to *B*' is not covered.

NOTE 2 — A multi-purpose instrument capable of measuring more than one physical quantity has a separate range for each such quantity.

2.16 Graduation — The process of setting out a scale.

NOTE — The use of the word 'graduation' alone in the sense of a 'graduation mark' is deprecated.

2.17 Scale Factor

2.17.1 For an instrument having an arbitrary scale, the factor by which the indication shall be multiplied to obtain the nominal value of the quantity measured.

2.17.2 For multi-range instruments having a scale (or scales) graduated in units of the quantity measured, the factor by which the indicated value shall be multiplied to obtain the nominal value of the measured quantity in the range being used.

2.18 Major Scale Mark, Major Mark — The scale marks which form the primary division of the scale. Major marks are emphasized generally by elongation relative to the minor marks.

2.19 Intermediate Scale Mark, Intermediate Mark — The scale marks which may be used, in some instances, to emphasize certain minor marks for the purpose of providing guidance in reading the scale between the major scale marks.

*The term 'scale division' is defined at **2.11** and this term should not be used in the sense of definitions **2.7, 2.12** and **2.13.**

2.20 Minor Scale Mark, Minor Mark — The scale marks which form the secondary division of the scale. Each interval between the major scale marks is divided into a number of scale divisions delineated by minor scale marks.

2.21 Scale Plate, Dial — The face of an instrument on which the scale is delineated. This includes all the area observed which will normally be somewhat greater than the area that will accommodate the scale alone.

2.22 Scale Plate (or dial) Blank — The material on which the scale and its background are marked or reproduced.

2.23 Accuracy — A general term describing the degree of closeness with which the indications of an instrument approach the true values of the quantities measured.

2.24 Accuracy Grade — The category into which an instrument falls by virtue of the specified limits of error with which it purports to comply.

2.25 Observation Error, Reading Error (Deprecated) — The error made by the observer when reading the indication of an instrument.

NOTE — Observation errors may be due, for example, to paralax, or to simple misreading of the indication.

2.26 Resolution — The smallest fraction of one scale range to which a reading is to be made.

2.27 Interpolated Spacing — The distance, on the scale base, corresponding to one part of the scale spacing when the latter is subdivided by eye into a number of equal parts.

2.28 Interpolated Interval — The increment of the measured quantity corresponding to the interpolated spacing.

3. GENERAL CONSIDERATIONS

3.0 These recommendations are based on the following considerations.

3.1 In general usage, the instrument is observed for the purpose of reading from some distance when it is directly facing the observer and for a brief period only. For the purpose of this recommendation, an observation time of two seconds has been assumed and it is expected that the stated observation accuracy will be achieved within this time.

3.2 It is essential that:

a) the scale and the figuring shall be clearly laid out, and

b) there shall be proper visual co-ordination between the pointer and the scale marks and between the scale marks and the associated numerals.

3.3 The spacing of the scale marks and their thickness shall be such that they are clearly legible at a maximum distance at which the instrument is expected to be read.

3.4 For achieving the legibility, the scale length may be made larger for the distance at which the scale is to be read, but this unnecessarily makes the instruments large where the economy as well as limited space demand are to be considered.

3.5 To indicate the difference in the area occupied by the same scale having different configurations, a comparison is made in Fig. 3. The scales shown in Fig. 3 having straight, 90° sector and part circular configuration are identical in scale base length, subdivision, and dimensions of graduations and numerals.

3.6 Open scales, that is, the scales without too many scale marks read by interpolation of the scale divisions to not finer than one-fifth of division, are read most easily and with minimum errors.

3.7 The interpolated spacing should be related to maximum distance at which the scale is to be read so that the ratio (that is the angles subtended at the eye of the observer) is not less than a certain critical value, otherwise observation errors increase rapidly.

3.8 The number of interpolated spacings chosen for scale will depend upon the resolution required which will be based on operational needs and may be related to the intrinsic accuracy of the instruments. In the optimum basic scale, adopted in this standard, reading to one percent of scale range is taken as the most desirable so that there will be one hundred interpolated spacings.

3.9 By considering **3.6** and **3.7**, a relationship may be established relating to maximum reading distance and scale base length.

3.10 The effective numbering of interpolated division, minor divisions and major divisions should all proceed in 1's, 2's or 5's (or decimal multiples or sub-multiples of these). These number of divisions making up next larger division, (for example) interpolated to minor or minor to major would be 5 and 4 respectively to maintain numbering only in these values.

4. OBSERVATION AND ACCURACY

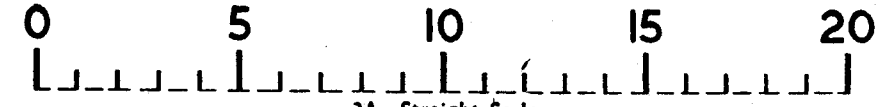
4.1 The principal factors which affect the observation accuracy are:

a) the conditions under which observation is made,

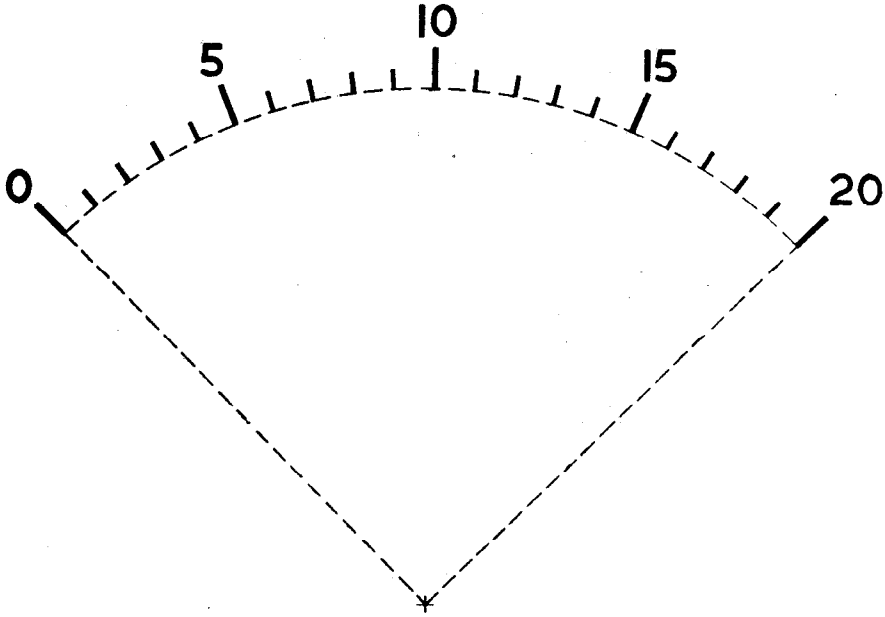
b) eyesight,

c) practice, and

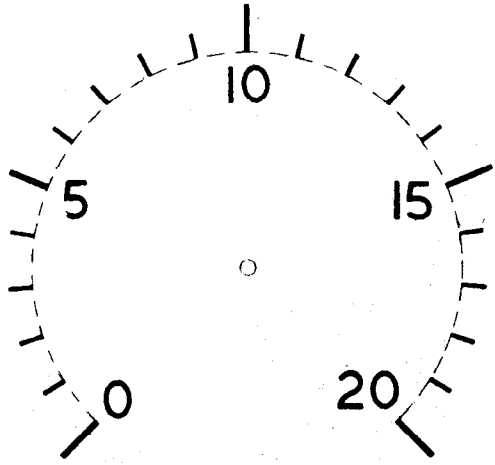
d) age of the observer.



3A Straight Scale



3B 90° Sector Scale



3C 270° Part Circular Scale

AREA OCCUPIED BY THE SAME SCALE IN DIFFERENT FORMS

4.1.1 *Observation Conditions* — For ease of observation, it is required that the dial of the instrument should be illuminated by brightness of at least 0·010 76 Lamberts (10 foot-Lamberts). It is also required that the line of sight should, as far as possible, be normal to the plane to the indicator scale.

4.1.2 *Eyesight of Observer* — The recommendations allow the usual ratings corresponding to 6/9.

4.1.3 The practice of reading the instruments improves the accuracy of observation.

4.1.4 *Age of Observer* — The age of the observer will have considerable effect on observation accuracy, in particular to eyesight. The recommended eyesight is 6/9 or better at designed observation distance. Older people may take longer than two seconds to make an observation.

4.2 It is expected that if care is taken for the factors mentioned in **4.1**, a reading shall not depart from the indicated value by more than one percent of the scale range in 90 percent of the observations made.

5. READING DISTANCE AND SCALE BASE LENGTH

5.1 The basis of setting out all the scales is the scale base length which is dependent upon the maximum distance at which the instrument can be read with a minimum number of mistakes. The dimensions of the scale are not dependent upon the size of the dial or instrument in which the scale is incorporated. They also do not depend upon the shape of the scale whether full circle, part circle or straight.

5.2 A person of normal eyesight under good lighting conditions can read a well laid out scale set out in accordance with these recommendations, with a minimum number of incorrect readings when the smallest interval reading on the scale subtends approximately two minutes arc at the eye. This smallest interval may be a sub-division ' by eye ' into five parts of a scale division. Subdividing into more than five parts results in greater inaccuracy and subdividing into less than five parts does not result in any improvement in the required number of correct readings.

5.3 It is considered that a scale readable to one percent of scale range is generally acceptable for bold presentation and rapid reading. As this will be one-fifth of a division, there should thus be $100/5 = 20$ divisions in the total length of the scale for optimum design.

5.4 In consideration of the facts given in **5.2** and **5.3**, the relation between the maximum reading distance ' D ' and the scale base length 'L ' is given by $D = 18\ L$, but in practice $D = 14{\cdot}4\ L$ is recommended, to take into account the possible errors in reading, unfavourable lighting conditions and poor eyesight and any other thing that will affect the observation accuracy

From this, the scale base length may be calculated when the maximum distance at which the instrument is to be read is known (*see* Table 1).

5.4.1 In case of instruments with both positive and negative values (for example centre-zero instruments), the normal relationship given in **5.4** holds good provided both positive and negative values are in the same units. It should be realized that the scale base length and the number of divisions apply to the total length of scale, that is, positive and negative values taken together.

TABLE 1 READING DISTANCE AND SCALE BASE LENGTH

(*Clause* 5.4)

Reading Distance D	Scale Base Lengths Based on the Formula $L = \frac{D}{14 \cdot 4}$	Optimum Scale Spacing Based on 20 Divisions
(1)	(2)	(3)
m	mm	mm
0·6	42	2·1
1	70	3·5
1·6	112	5·6
2·5	174	8·7
4	278	13·9
6	416	20·8
10	700	35·0

6. GENERAL DESIGN OF SCALES

6.1 In these recommendations, it is expected that the reading to one percent of the scale range is reasonable for the class of instruments mentioned. It is evident that the optimum number of scale divisions is one-fifth of hundred, that is 20. This being the value already adopted in determining the scale base length and reading distance relationship.

6.2 Because of the uniform type of dial lay-out, the basic scale (without figuring) may be photographically enlarged or reduced to all sizes of instruments. The dials may subsequently be figured to suit all customary scale ranges. This is an advantage to the manufacturer while designing the scales.

6.3 The adoption of these recommendations will tend towards a uniformity of appearance in all of the instruments on any one panel. This has got a practical advantage that a uniform method of subdivision will ensure quicker

and more accurate reading of the dials having differing maximum scale readings.

6.4 Numbering of Major Marks — The preferred series of unit designation numbers, that is, the numbers attached to the major marks are as follows:

System A, Numbering by 1's (or 10's) :
0, 1, 2, 3, 4, 5, 6.....(or 0, 10, 20, 30, 40, 50, 60)

System B, Numbering by 2's (or 20's) :
0, 2, 4, 6, 8, 10.....(or 0, 20, 40, 60, 80, 100.....)

System C, Numbering by 5's (or 50's) :
0, 5, 10, 15, 20.....(or 0, 50, 100, 150, 200)

6.5 Series such as 0, 1·5, 3, 4·5 and 0, 2·5, 5·0, 7·5 (or multiples) should not be used.

6.5.1 Unit designation numbers should be placed only against major scale marks (*see* Fig. 4).

6.6 The number of scale divisions between numbered marks should not exceed five.

6.7 Arrangement of Minor Marks — Since minor marks have to be numbered mentally by reference to the numbered major marks, an easy addition is necessary. The effective numbering of minor marks should be in 1's, 2's or 5's or multiples of these by 10 or 0·1. The minor marks should not be divided into units of 4. The arrangements such as 2·5 unit per scale division should also be avoided. This means that there should be four minor divisions between the adjacent major marks, if the major marks are numbered in 2's; and there should be five minor divisions, if the major marks are employed in 1's or 5's.

6.7.1 There will be four minor divisions between the adjacent major marks in the scales in which the major marks are numbered in 2's. Therefore, there will be three minor scale marks and it is convenient to have central minor marks, so that 1's are more prominent. These central minor marks become intermediate mark and they should be of same length as major marks but remain unnumbered. The scales having such intermediate marks will have a different appearance from all the other scales which have major marks numbered in 1's or 5's.

6.8 Scale Ranges — The scale ranges adopted in these recommendations are for guidance only. Depending on the particular use of the instrument, it may become necessary to adopt other scale ranges in which case these recommendations should be followed in principle.

6.9 Dimensions for Scale Marks — The recommended thickness and lengths for scale marks are given in Table 2.

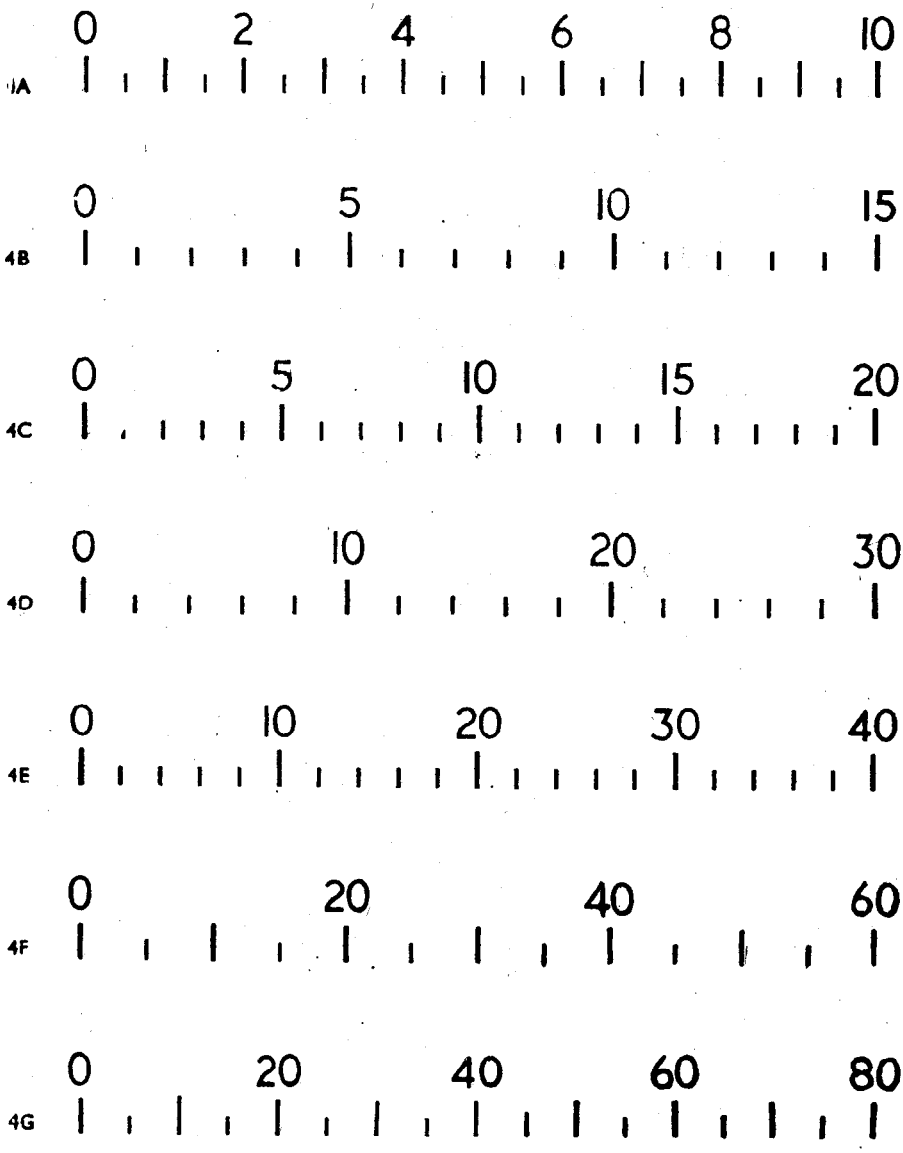


FIG. 4 PREFERRED SCALE RANGES AND THEIR DIVISIONS

TABLE 2 DIMENSIONS FOR SCALE MARKS

(*Clause* 6.9)

	Ratio to Scale Base Length	
	Nominal Thickness	Nominal Length
Major marks	0·004 5 or 0·006 7	0·042 up to 0·050
Minor marks	0·004 5	0·025
Intermediate marks (if used)	Same as major marks	Same as major marks
Boundary line (if used)	0·002	—

6.9.1 It is necessary that the major scale marks should be prominent as placing of numerals against the major scale marks is not sufficient. It is not only necessary to increase the thickness of major scale mark but also to increase the length. The increase in the length of major marks should be away from the index (*see* Fig. 1 and 3). In these recommendations, two alternative thicknesses of major marks are given because the major marks which are of the same thickness as of minor marks appear to the eye to be slightly thinner than the minor marks. The choice whether the major marks should be of the same thickness as the minor marks or more (say by 50 percent) will be influenced by the use or omission of boundary line. It is also influenced to some extent by the angularity of the scale (whether full circle, part circle or straight) and whether the numerals are placed inside or outside of the scale.

6.9.2 The portion of the major marks which extends beyond the length o the minor marks should be increased in thickness so as to signify the majo marks. This ensures that all the marks on the scale are of the same thickness and the spaces between all marks are the same, the significant part of the major mark being outside the area of the scale swept by the index.

6.9.3 The ends of scale mark may be either square or rounded. When rounded, the scale marks may be of the same overall length as those recommended for square ended marks (*see* Fig. 5).

6.9.4 The radial marks on circular scales should have both sides parallel throughout their length. These should not be wedge-shaped in a manner that the prolongation of both sides of the mark passes through the centre of the dial.

6.10 Boundary Lines — It is preferred that the boundary lines should not be used. If the boundary line is desired, not more than one should be used and its edge adjacent to the scale marks should be coincidental with the scale base (*see* Fig. 6).

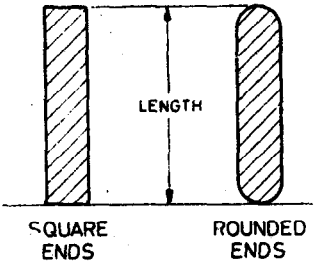


FIG. 5 SCALE MARKS

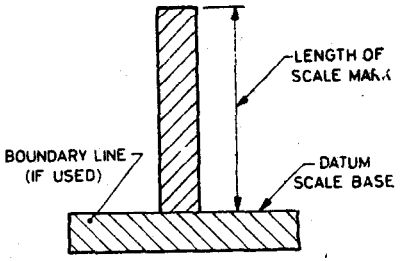


FIG. 6 RELATIONSHIP OF SCALE MARK AND BOUNDARY LINE TO DATUM (SCALE BASE)

6.11 Circular Scales — In case of single circular scales, the placing of numerals may be either outside or inside the scale marks. If the numerals are outside the scale marks, the scale base length will be shorter in a given dial size or conversely. A larger instrument case should be used to give the same scale length as one having the numerals inside the scale marks. It is, therefore, recommended that numerals may be placed inside the scale marks though this gives rise to the disadvantage that pointer will partly obscure the numerals.

6.12 Sector Scales — In the sector scales embracing an arc between 60 and 100°, the placing of numerals outside the scale marks does not appreciably shorten the scale for any given scale size. This is recommended as this does not lead to obscuring of the numerals by the pointer. The placing of the first and the last numeral inside the scale marks will achieve the maximum scale length. This also may be used as alternative.

6.13 Straight Scales — In straight scales, whether horizontal or vertical, the numerals should always be on that side of the scale marks which is opposite the index, since the wide indexes for such scales mask an appreciable portion of the dial. It is recommended that (apart from special considerations such as the association of two instruments on a panel where for aesthetic

reasons or for ease of taking comparative readings it may be desirable for instruments to be of opposite hand) the numerals should appear on the left of vertical straight scales and, where practicable, above horizontal straight scales.

7. FIGURING AND LETTERING

7.1 Unit Designation — The unit designation, for example kgf/cm^2, should always be clearly indicated on the dial as briefly as possible. Wherever practicable, the position of the unit designation on the dial should be outside the area swept by the pointer. The unit designation should always be given by the recognised abbreviations. In case there is no recognized abbreviation, a proper abbreviation should be devised, if possible, otherwise the dial will become overcrowded and readability impaired. The abbreviated unit designation is sufficient to indicate the function of the instrument. The additional words, such as ' pressure ' or ' height ', are redundant and overcrowd the dial.

7.2 Scale Factors — The use of scale factors should, as far as possible, be avoided because it may lead to misinterpretation of action to be taken to apply the scale factors. With some units, the scale factor may be avoided by proper selection of the expression for unit designation.

7.3 Unit Designation Numbers — The number of digits in the unit designation numbers should, as far as possible, be below three except for the maximum scale value. Where the unit chosen results in more than three digits, it is necessary to choose a unit of larger value.

7.4 Design of Numerals — For the purpose of these recommendations, a numeral is understood to comprise one or more digits. The recommended form of numerals for use on dials and scales shall be shown in Fig. 7. These provide the maximum legibility up to the recommended maximum reading distance and at the same time to be reasonably compact and suitable for use on dials where the available space is limited. If it is found necessary, the square shape of the ends of the strokes on certain digits as shown in Fig. 8 may be modified. This may be done either by radiusing the corner (Fig. 8, Example A) or by full radiusing of strokes (Example B). In both the methods, the radiusing should be within the boundary of the shape of the digit shown in Fig. 7, that is, the central line length of the stroke should remain the same excepting in case of digits 6 and 9, where the rounded outline should be so located as to touch the horizontal line which bound the general overall height of the figures (Fig. 8, Example B). The recommendations given for the overall height of the digits and spacing between them apply equally to digits of these modified shapes. For maximum legibility and also for good appearance, the spacing between the digits comprising in numerals is as important as the form of digits themselves. The spacing between recommended adjacent digits should be as given in

Table 3. The spacing which has horizontal distance between the nearest point of the adjacent digit is given in terms of the height of the digit. The distance between the end of the scale mark and the nearest point on a numeral (between the boundary line and nearest point on a numeral) should preferably be equal to one-half the width of the digit 0.

TABLE 3 SPACING BETWEEN ADJACENT DIGITS

Combination of Digits	Spacing (in Digit Height) Between Nearest Points of Digits
10	0·21
12	0·21
15	0·18
20	0·14
25	0·14
30	0·15
40	0·11
50	0·17
60	0·14
75	0·07
80	0·14
90	0·14
00	0·12

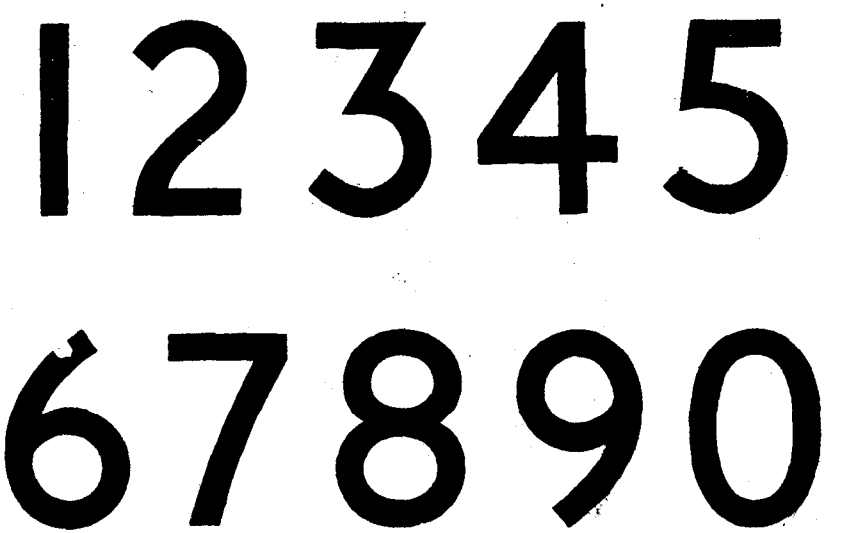


Fig. 7 Recommended Series of Figures

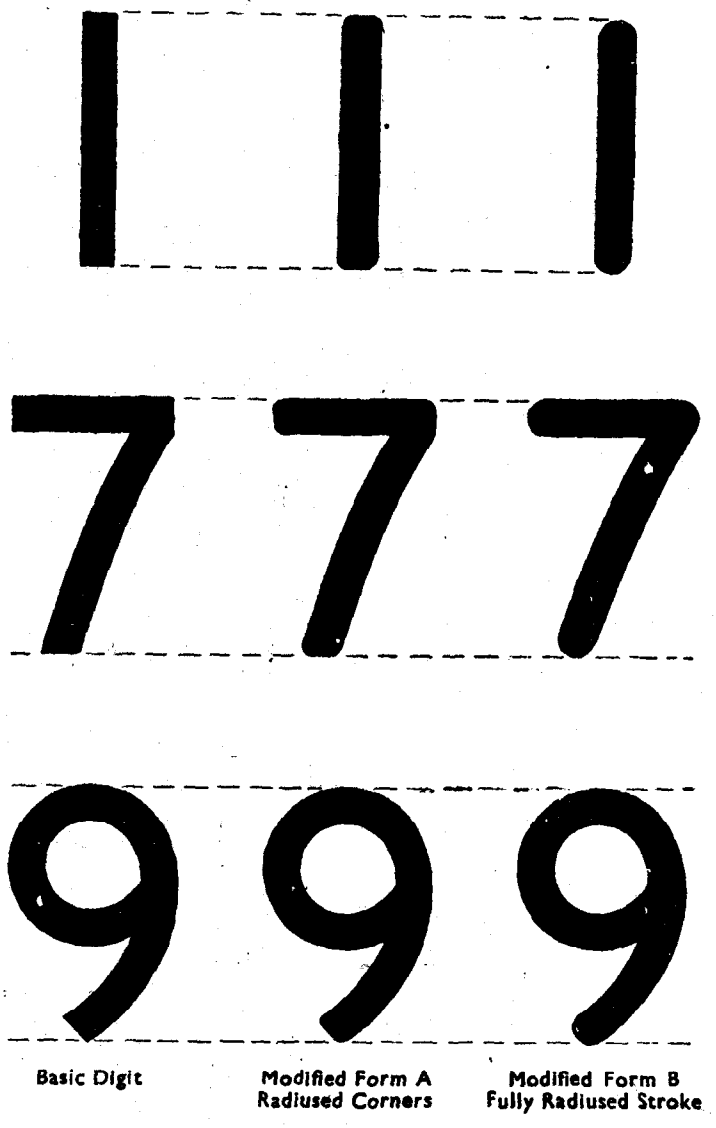


FIG. 8 MODIFIED SHAPE OF DIGITS

7.4.1 The recommended form of digits and their geometric construction for use on dials and scales is given in larger detail in Appendix A and Appendix B respectively.

7.4.2 All numerals should be orientated in the normal viewing position; the numerals should not be orientated tangentially to radial scale marks (*see* Fig. 9) except in the case of horizontal sector scales.

7.4.3 The numerals should be so located in relation to the scale that a prolongation of the scale mark would pass through the visual and geometric centre of the complete numeral (*see* Fig. 10). It is appreciated that the application of this recommendation in respect of circular scales may mean that numerals on opposite sides of scales, for example, a commencing 0 and a terminating 200 will be at slightly different levels. While this represents a departure from the conventional practice, the legibility of the scale is improved by adhering to the recommendation.

7.4.4 It is not justifiable to expect the manufacturers to replace their existing equipment in order to adopt these recommended digits because the changeover is not economical. The digits used by the manufacturers may differ from the recommended digits and possibly from the digits used by another manufacturer and until such times as change in techniques or other reasons allow closer accordance to emerge naturally.

FIG. 9 ORIENTATION OF NUMERALS

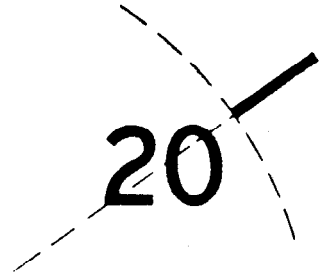


FIG. 10 POSITION OF NUMERALS RELATIVE TO SCALE MARK

7.5 Design of Letters

7.5.1 Where it is considered that the unit designation is readable at the maximum reading distance appropriate to the scale base length, the height of a capital letter of the unit designation should be the same as the height of numerals associated with the scale marks. It is neither essential nor necessarily desirable that the unit designation should be given in capital letters; many standard abbreviations call for the use of 'lower case' letters, but provided that the lower case letters are no smaller than those appropriate to the height of capital letter, it may be assumed that words and symbols incorporating such lower case letters will be readable at the maximum reading distance.

7.5.2 Rounded ends to the strokes of letters may be used, as for the numerals, if desired and the same general principles should be followed.

7.5.3 It has not been considered necessary to design a special type of lettering. The type should be 'sans serif', in conformity with the numerals. A type similar to the printers' type 'Gill Sans*' is recommended.

7.6 Other Markings on Dials — Other markings on dials shall mean the markings other than the figuring on the dial in relation to the scale divisions and to the lettering concerned with unit designation which are dealt with in **7.1, 7.3, 7.4** and **7.5.** The other markings are of subsidiary nature or minor character, much of which is required only when first connecting up or replacement is necessary and may be placed under the following headings:

a) Characteristics of the instrument,

b) Precautions in use,

c) Maker's marks, and

d) Position in circuit.

7.6.1 *Characteristics of the Instruments* — The type of the instrument, special features, internal characteristics, calibration factors or marks, class of accuracy, number if any, use with auxiliary apparatus test conditions, etc, come under the characteristics of the instruments. To reduce the area occupied by these, only standard abbreviations and accepted symbols should be used.

7.6.2 *Precautions in Use* — For permanently installed instruments, the information regarding the precautions in use will be of secondary nature and need not be placed on the main dial space. For other instruments, the information regarding precautions should be given prominently, but should be kept clear of the area swept by the pointer.

*The words 'Gill Sans' are the correct designation of medium weight letter.

7.6.2.1 If statutory regulations require, the markings should indicate the par icular medium with which an instrument may only be used. This may be conveniently added to the unit designation.

7.6.3 *Maker's Marks* — These include the manufacturer's name, trademark, serial number, patent numbers, etc.

7.6.4 *Position in the Circuit* — The information regarding the position of the instrument in the circuit or with a particular machine should be placed external to the instrument either by a label or sign writing on the panel or by any other appropriate means. It shall in no case be included on the dial or on the instrument.

8. INDEX OR POINTER

8.1 The pointer of an instrument should indicate a location against a scale and should be easily and quickly visible. The design of pointer for circular and sector scales will be different from the design of pointer for straight scale because in circular and sector scales the position changes in relation to the scale are achieved by means of the angular rotation of the pointer which gives a readily apparent indication of such changes whereas the pointer on a straight scale gives no angular indication of its position. The body of the index should be of sufficient area to catch the eye, and should be so shaped as to lead the eye to the scale. In straight scales, the visible portion of the pointer is restricted in length and so the widt should be such that it gives adequate area to catch the eye.

8.1.1 *Pointers for Circular or Part Circular Scales* — For accuracy of location, the tip of the pointer shall be made narrow and the body should be made moderately wide to achieve necessary boldness taking care to see that it does not mask the numerals excessively. It is recommended that the end of the pointer should have a width nearly equal to the thickness of the minor mark. The tip may be finished square, rounded or to an included angle of not less than 60°, spades on pointers should not be used. As far as possible, a tailless pointer should be used with circular scales. In case it is not possible to avoid a tail, it should be compact and should not come close to the scale or numerals. The pointer should not extend very much beyond the outer end of the minor scale marks and should be as small as possible and in no case shall overlap more than one-third of the length of the minor scale marks.

8.1.2 *Indexes for Straight Vertical or Horizontal Scales* — It is recommended that the area enclosed by the index should be similar to that of the rectangle bounding the digit 0 used for the scale numbering of that instrument. The overlap of the minor marks should be as small as possible and shall not be more than one-third of a minor scale mark. The index should be located on the opposite side to that of the numerals. As far as possible, there should be clearance between the base of the pointer and the bezel or spacer of the instrument case.

8.2 Direction of Movement — For normal instruments, the direction of movement of the index to show increasing magnitude of the indicated quantity should be as given in Table 4.

TABLE 4 DIRECTION OF MOVEMENT OF INDEX

TYPE OF SCALE	ILLUSTRATED IN	DIRECTION OF MOVEMENT
Circular scales	Fig. 2A and 2B	Clockwise
Horizontal sector scales (either top or bottom)	Fig. 2C and 2D	From left to right
Vertical sector scales	Fig. 2F and 2G	
left hand		Upwards (that is clockwise)
right hand		Upwards (that is anti-clockwise)
Quadrant scale (upper left)	Fig. 2E	Clockwise
Straight (edgewise) scales	Fig. 2H and 2J	
vertical		Upwards
horizontal		From left to right

8.2.1 Centre zero or displaced zero scales may be considered as a combination of two separate indications, both of increasing magnitude but of opposite signs. In such scales, the section to the right of, or above the zero, should follow the recommendations given above, whilst section to the left of, or below the zero, will be the reverse of the above recommendations.

9. COLOURING AND SURFACE FINISH OF DIAL MARKINGS, BEZELS, INDEXES AND POINTERS

9.1 Plated bezels should be avoided and uniform dark colour bezels of a shining surface should not be employed. Bezels should not be made unduly broad or elaborate in section. White or off white should be used for the dial while black colour should be used for black scale markings and black pointer. The reflectivity factor for white should be at least 80 percent for white colour and the reflectivity factor should not be more than 5 percent for the black colour. Instruments with black dials and white scale markings and pointer which are to be read at low levels of illumination should have the bezel coloured matt black so that it virtually becomes an extension of the dial. The spacer or the equivalent part of the case should be of such a material and such a surface finish as neither to cause dazzle nor make a strong contrast with the dial. Set-point indicators should be distinctive in shape and/or colour. To avoid heavy shadows on the dial when the instrument is illuminated obliquely, the dial should be brought as far forward as possible in the case. The enclosing glass should be flat,

otherwise the form of convexity will result in undesirable distortions or specular reflections under certain lighting conditions.

10. VIEWING ANGLE AND PARALLAX ERRORS

10.1 To reduce the error of parallax, the indicating tip of the pointer should be as close to the dial as practicable. In case of platform scales, parallax will not occur if the instrument is viewed obliquely. The gap between the scale marks and the pointer should be as small as practicable, otherwise an error may be introduced to the necessity of visually projecting the pointer on to the scale. Dials with platform scales should not be illuminated obliquely, as a shadow may be cast on the numerals. If it is not possible to avoid oblique lighting, it is desirable to increase the general recommended distance between the numerals and the ends of scale marks; with this type of scale, boundary line should not be used. The recommendations for platform scales will also hold good to the scales in which the indexes are mounted flush with the scale.

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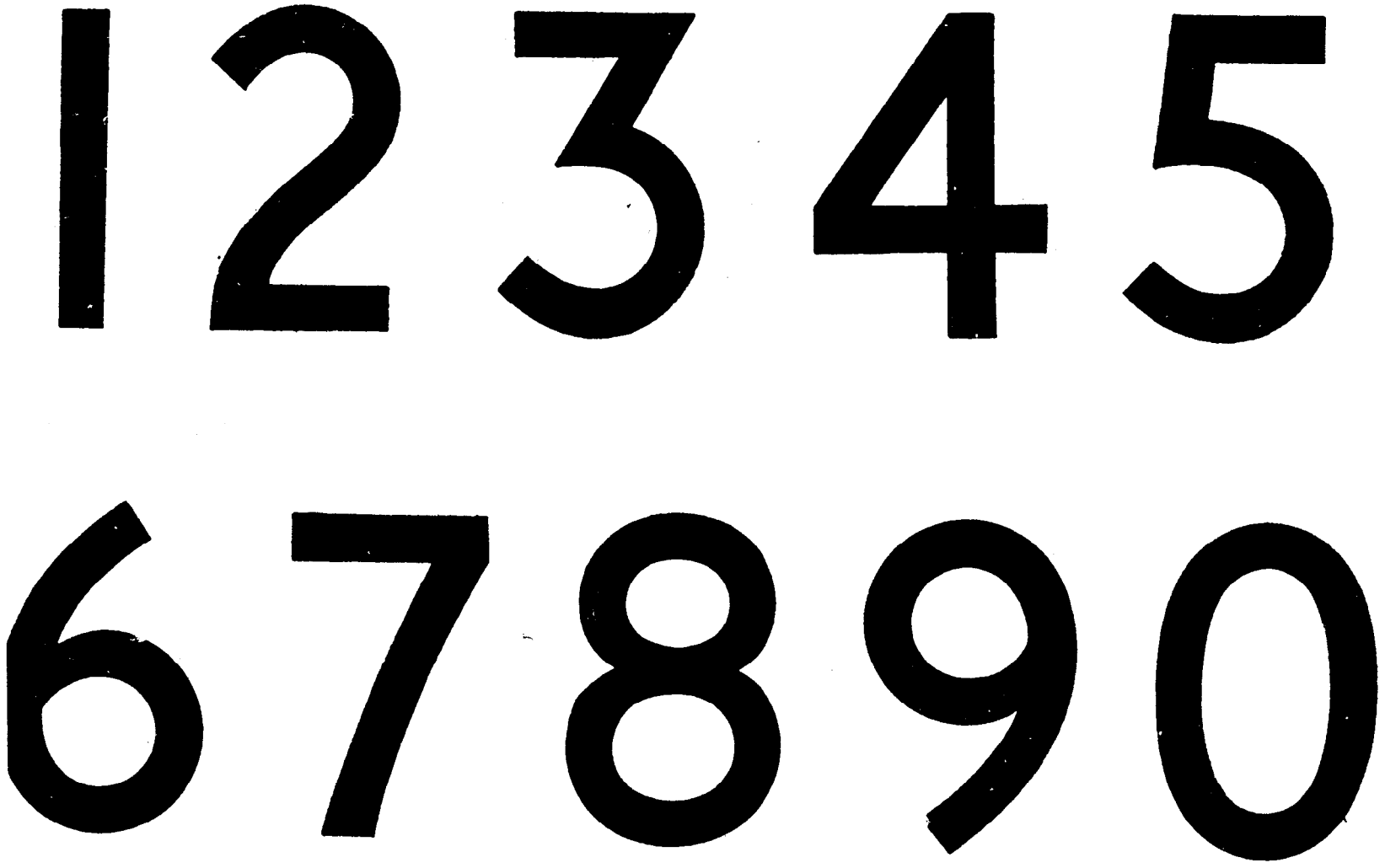
APPENDIX A

(*Clause* 7.4.1)

RECOMMENDED FORM OF DIGITS



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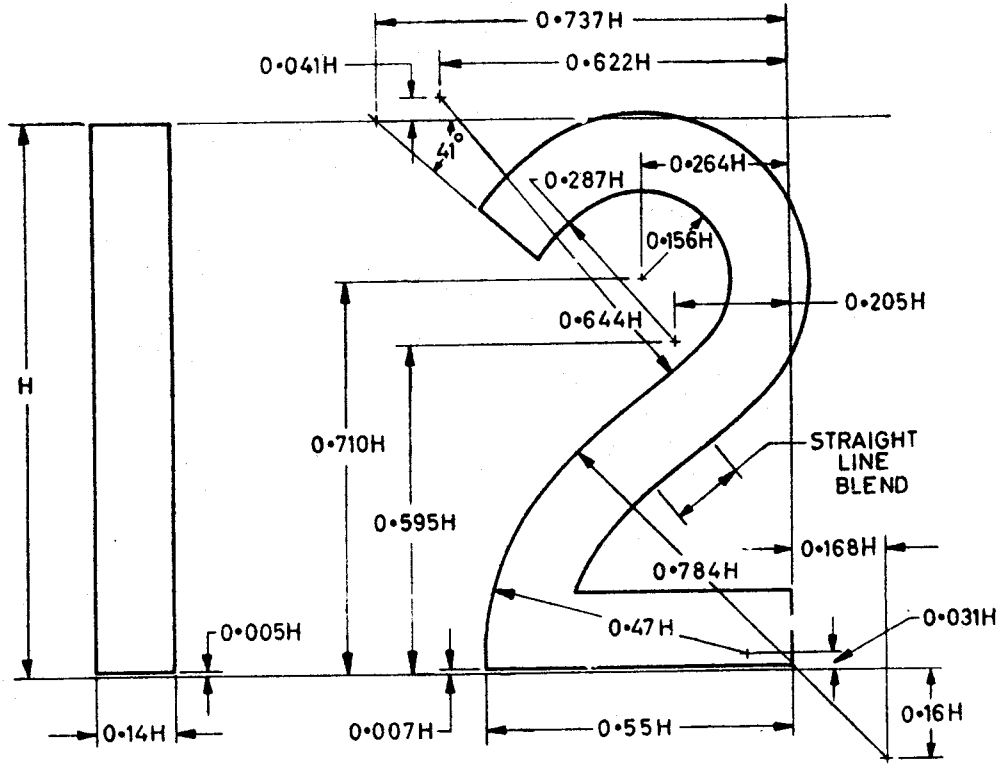
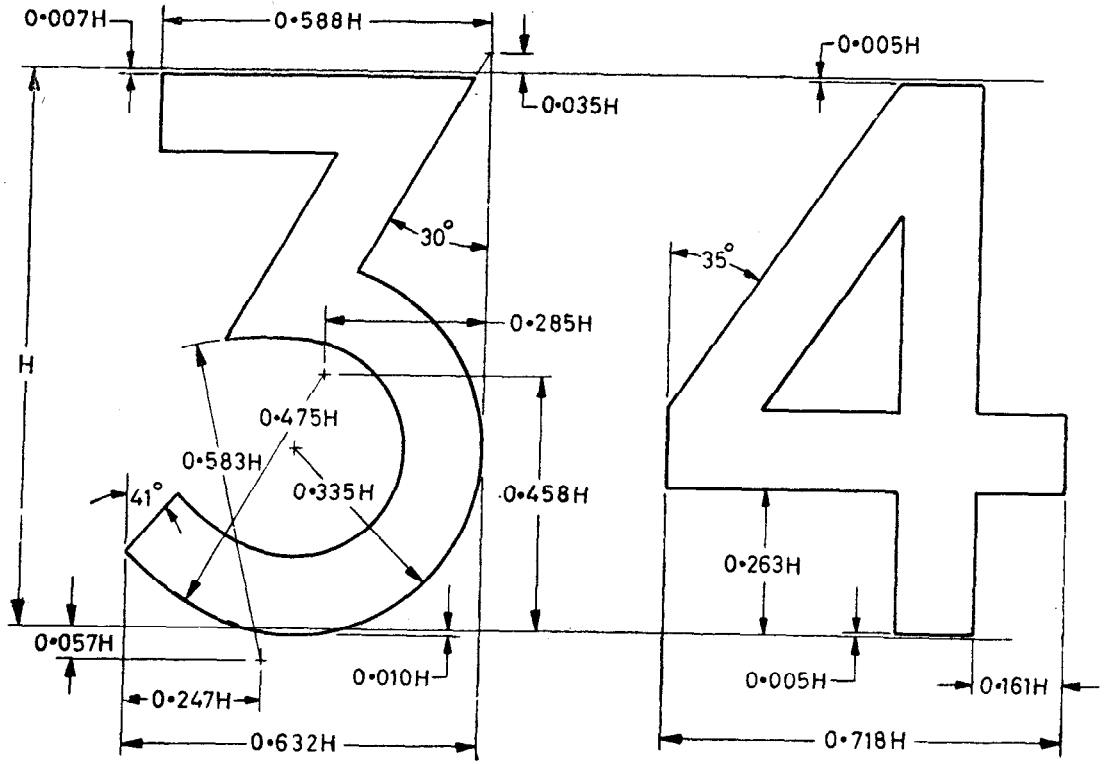
APPENDIX B

(*Clause* 7.4.1)

GEOMETRIC CONSTRUCTION OF DIGITS



APPENDIX B — *Contd*



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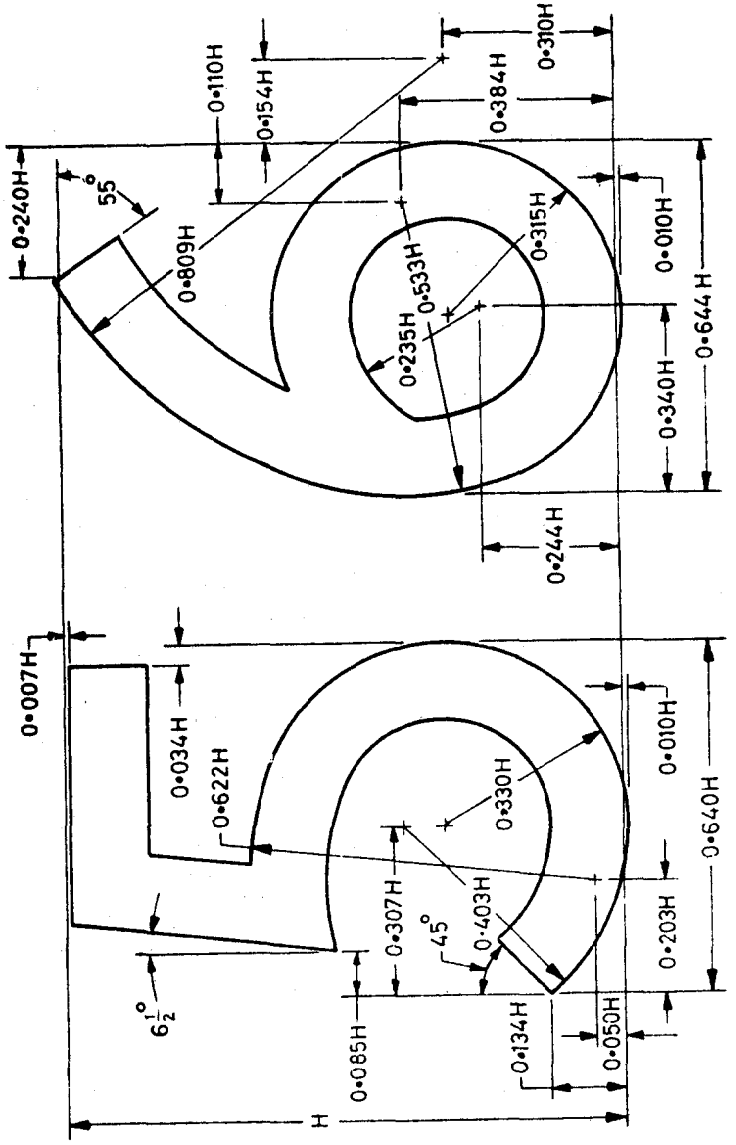

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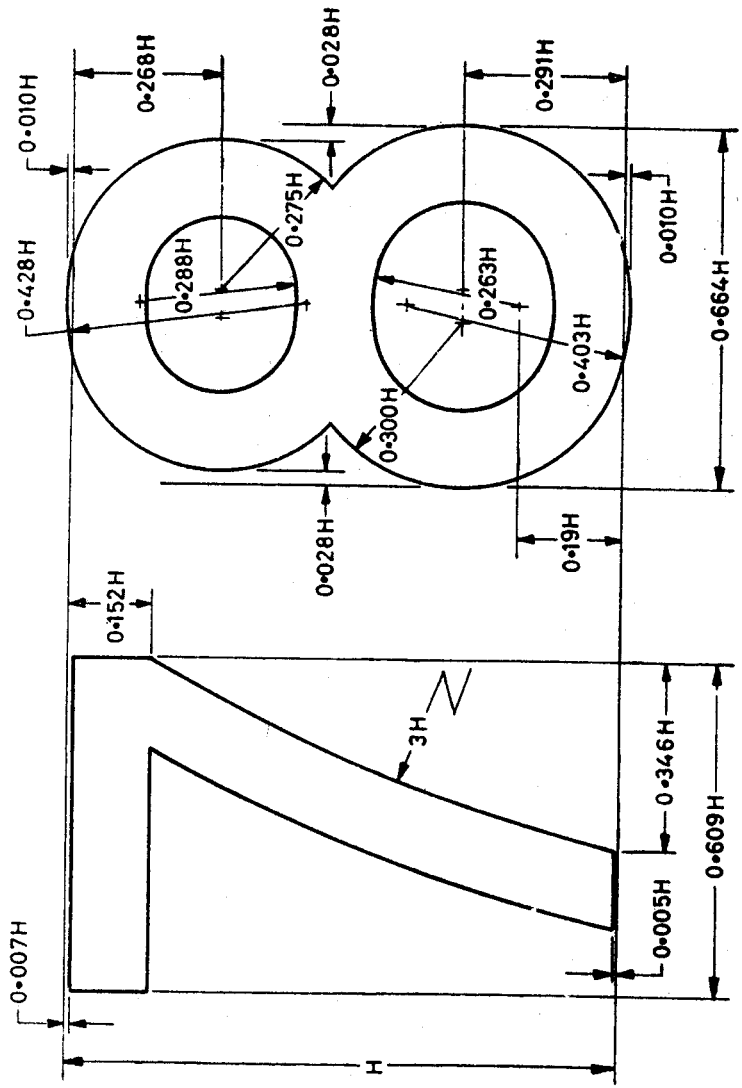

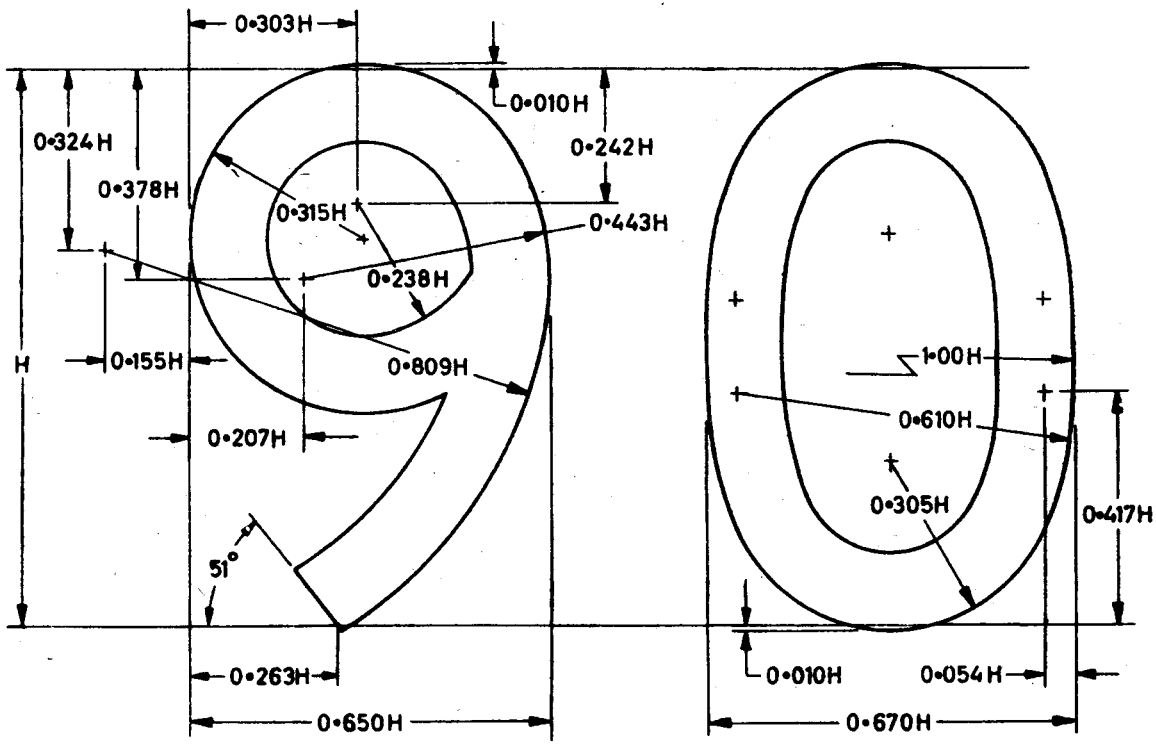
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0·324H
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0·207H
51°
0·263H
0·650H
1·00H
0·610H
0·305H
0·417H
0·010H
0·054H
0·670H

INTERNATIONAL SYSTEM OF UNITS (SI UNITS)

Base Units

Quantity	*Unit*	*Symbol*
Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Thermodynamic temperature	kelvin	K
Luminous intensity	candela	cd
Amount of substance	mole	mol

Supplementary Units

Quantity	*Unit*	*Symbol*
Plane angle	radian	rad
Solid angle	steradian	sr

Derived Units

Quantity	*Unit*	*Symbol*	*Definition*
Force	newton	N	1 N=1kg.m/s^2
Energy	joule	J	1 J=1 N.m
Power	watt	W	1 W=1 J/s
Flux	weber	Wb	1 Wb=1 V.s
Flux density	tesla	T	1 T=1 Wb/m^2
Frequency	hertz	Hz	1 Hz = 1c/s (s^{-1})
Electric conductance	siemens	S	1 S=1 A/V
Electromotive force	volt	V	1 V=1 W/A
Pressure, stress	Pascal	Pa	1 Pa=1 N/m^2

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